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## Foehn wind as a seasonal suicide risk factor in a mountain region

### Wiatr fenowy jako sezonowy czynnik ryzyka samobójstwa w regionie górskim

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#### Abstract

**Objective:** The belief that the foehn wind has an impact on suicide is firmly rooted in local culture in various mountain regions of the world, but scientific data on this subject are limited. In this study, the hypothesis of a possible relationship between Halny (foehn type wind occurring in the Polish part of the Tatra Mountains) and the risk of suicide was examined. **Method:** The number of suicides recorded in the years 1999–2014 by the Police Office in the Tatra region in the context of diurnal meteorological data was defined. Foehn was defined as a set of various meteorological factors, including changes in air pressure, temperature, humidity, cloud cover as well as wind direction and speed. The days on which favourable conditions for the occurrence of the foehn wind and the two days preceding the phenomenon were taken into account. The relative risk of suicide was calculated. **Results:** 210 cases of suicides were recorded during the study period, of which 14.5% occurred on the foehn wind day. The suicide rate was similar throughout the year, regardless of the season. Halny did not change the overall daily risk of suicide, but could have had an impact on the seasonal risk of suicide ( $p < 0.05$ ). In two groups of foehn wind, relative risk increased more than fourfold in summer and twice in autumn, and in spring it decreased tenfold. **Conclusion:** There are no clear links between the occurrence of the foehn wind and suicides. The foehn wind could increase the risk of suicide in the Tatra Mountains in the summer and autumn of the analysed period. Further research is needed to explain a possible relationship between foehn winds and suicide as well as to apply the research results in this field in suicide prevention in the mountain regions.

**Keywords:** suicide, risk factors, foehn wind, Halny, seasonality

#### Streszczenie

**Cel:** Przekonanie, że wiatr fenowy ma wpływ na samobójstwa, jest mocno zakorzenione w lokalnej kulturze w różnych regionach górskich świata, niemniej jednak dane naukowe dotyczące tego tematu są ograniczone. W niniejszej pracy badano hipotezę możliwej zależności między halnym (wiatr typu fenowego występujący w polskiej części Tatr) a ryzykiem samobójstwa. **Metoda:** Dokonano analizy liczby samobójstw odnotowanych w latach 1999–2014 przez urząd Policji w powiecie tatrzańskim w kontekście dobowych danych meteorologicznych. Fen zdefiniowano jako zespół różnych czynników meteorologicznych, w tym zmiany ciśnienia powietrza, temperatury, wilgotności, zachmurzenia, prędkości i kierunku wiatru. Zostały wzięte pod uwagę dni, w których pojawiły się warunki sprzyjające wystąpieniu wiatru halnego, oraz dwa dni poprzedzające zjawisko. Obliczono względne ryzyko samobójstwa. **Wyniki:** W okresie badania zarejestrowano 210 przypadków samobójstw, z czego 14,5% miało miejsce w dniach ze zjawiskami fenowymi. Wskaźnik samobójstw był podobny przez cały rok, niezależnie od pory roku. Halny nie zmienił ogólnego dobowego ryzyka samobójstwa, jednak mógł mieć wpływ na sezonowe ryzyko samobójstwa ( $p < 0,05$ ). W dwóch grupach wiatru fenowego względne ryzyko zwiększyło się ponadczterokrotnie w okresie letnim i dwukrotnie w okresie jesieni, a wiosną obniżyło się dziesięciokrotnie. **Wniosek:** Brak jednoznacznych powiązań pomiędzy występowaniem halnego a samobójstwami. Wiatr fenowy mógł zwiększać ryzyko samobójstwa w Tatrach w okresie letnim i jesiennym analizowanego okresu. Konieczne są dalsze badania, aby wytłumaczyć możliwy związek wiatrów fenowych ze zgonami samobójczymi oraz aby wykorzystać wyniki tych badań do działań z zakresu zapobiegania samobójstwom w regionach górskich.

**Słowa kluczowe:** samobójstwo, czynniki ryzyka, wiatr fenowy, halny, sezonowość

## INTRODUCTION

Suicide is a complex phenomenon, strongly affecting individuals, families and societies. Multiple interacting factors influence the risk of suicide, including psychiatric and/or physical illness, previous and current traumatic social factors, suicide attempts and genetic susceptibility (Mann et al., 1999; Wasserman and Wasserman, 2009). Despite being recognised as contributors to suicide risk, meteorological factors remain poorly understood (Deisenhammer, 2003; Dixon and Shulman, 1983; Sulman, 1984). Their existence mostly goes unnoticed in the national, regional and local policies as well as in everyday psychiatric practice.

Foehns (Latin *favonius*, meaning “hot wind from the south”) are dry, warm, down-slope winds that occur in the downwind side of a mountain range, also often called ill-winds. They occur in the different regions of the world and cause property damages and avalanches (e.g. Foehn in the Alps, Halny in the Tatra region), wildfires (Santa Ana in southern California), pollution (e.g. Raco in Chile) and dust storms (e.g. Sharav in Israel) (San-Gil et al., 1991). Such winds have also been associated with increased crime and traffic accident rates (Odewald, 1939; Strauss, 2007). They are well recognised by the inhabitants of the regions where they blow e.g.: *I have neither heard nor read that a Santa Ana is due, but I know it, and almost everyone I have seen today knows it too. We know it because we feel it* (Didion, 1968). The belief that the foehn wind affects suicide rates prevails in local language and culture (Strauss, 2007). Qualitative studies suggest that the foehn winds can be predicted or sensed in advance by individuals living in the affected areas (Bartmiński, 2012). Halny is the foehn wind characteristic for the Tatra Mountains. The locals believe that it is associated with strange behaviour in some people, with the devil, sin and suicide by hanging: *As the wind blows strong, it is a sign that someone had hanged himself, Around the hanged man, devils are dancing, causing a terrible storm, swirls, whistles, breaking trees, roofs break* (Bartmiński, 2012).

The ill-effects of the foehn include physical complaints: pain, headache, nausea, circulatory dysfunctions and mental problems: anxiety, aggressiveness, restlessness, insomnia, sexual arousal, decreased self-control or weakness, tiredness, depression and apathy (Yackerson et al., 2012). However, many people do not experience the effect of the foehn at all (Weingärtner, 2000). Meteorological factors can be a trigger to suicidal behaviours in people with mental and social problems (Mills, 1934; Tromp and Bouma, 1973; Tsai and Cho, 2012). Rohden (1933) and Odewald (1939) found a significant increase in suicide incidence in Switzerland (and on the downwind side of the Alps) during the periods with foehn winds. Deisenhammer et al. (2003) did not confirm these results in Austria (1995–2000). Schiffer (1986) and Trepínska et al. (2005) reported the rise in the suicide rates during Halny winds in the Tatra Mountains, mostly in the summer.

## AIM OF THE STUDY

The aim of this study is the analysis of the temporal correlations between Halny winds in the Tatra County and the suicide occurrence in the 16-year period between 1999 and 2014. The hypothesis was that Halny wind increases the risk of suicide.

## MATERIAL AND METHODS

### Study area and its population

The Tatra Mountains are the highest part of the Carpathian chain, with an elevation of up to 2500 m above the sea level (asl). This location makes the Tatra Mountains a barrier to the incoming air from the south, contributing to the occurrence of the Halny wind. The weather in the region displays many features of alpine climate [a low average annual temperature, snow cover remaining for long periods, marked diurnal changeability of weather, high insolation levels, and strong winds (often of a hurricane force)]. The Tatra County is situated in the south of Poland, at the foot of the Tatra Mountains, on a 472 sq. km area with a total of 65 thousand inhabitants (52% of whom are women). A vast majority of the inhabitants are highlanders. The characteristic features of the community include: a considerable influence of the nature and climate, a major role of the Roman Catholic Church, an active and resourceful attitude, low unemployment and numerous organisations and associations operating in the fields of culture, sports and tourism. The highlanders describe themselves as religious, hard-working, and endowed with honour and dignity (Koszevska and Boguszevska, 2009, 2009–2010).

### Suicide data

The data concerning all suicides committed by the residents of the Tatra County [between January 1, 1999 and December 31, 2014 ( $N = 210$ )] were provided by the Main Police Headquarters. The dates of the committed suicides (as well as the age and gender of the suicide victims) were included in this study.

### Meteorological data and Halny criteria

The meteorological data were obtained every three hours from the two weather stations located in the Tatra County: Zakopane (855 m asl) and Kasprowy Wierch (1991 m asl). These stations operate within the Polish weather service network (Institute of Meteorology and Water Management – National Research Institute).

The Halny wind is considered a complex phenomenon influenced by many factors. It is a dynamic interaction of changing air pressure, air temperature, relative humidity and cloudiness. Therefore, in order to determine the Halny days, all the above mentioned meteorological data were taken into account. The three main criteria based on the

Suicide N = 210	Winter n = 51	Spring n = 56	Summer n = 52	Autumn n = 51
<b>Sex:</b> • Males, n = 168 • Females, n = 42	41 10	41 15	46 6	40 11
<b>Age:</b> • <25 years, n = 32 • 25–44 years, n = 69 • 45–64 years, n = 76 • >65 years, n = 33	8 18 17 8	6 17 27 6	12 15 16 9	6 19 16 10

Tab. 1. Seasonality of suicides in the Tatra County – 1999–2014

defined predictors (Brinkmann, 1971; Ustrnul, 1992) were determined:

- atmospheric circulation type favouring air flow from the South or South-West;
- vertical temperature gradient  $>0.8^{\circ}\text{C}/100\text{ m}$ ;
- co-occurrence of a particular wind speed (WS), wind direction (WD), cloud type (CT) and relative humidity (RH):  $WS \geq 5\text{ ms}^{-1}$ ,  $WD: 90^{\circ}\text{--}270^{\circ}$  and  $CT: \text{Alto cumulus lenticularis}$  or  $WS \geq 5\text{ ms}^{-1}$ ,  $WD: 90^{\circ}\text{--}270^{\circ}$  and  $RH \leq 70\%$  or  $CT: \text{Alto cumulus lenticularis}$  and  $RH \geq 70\%$ .

Every single day from 1999 to 2014 (a total of 5844 days) was classified in terms of the occurrence of the Halny criteria. The Halny class (HC) was attributed to each day, depending on the occurrence of one ( $HC = 1$ ), two ( $HC = 2$ ) or all the three ( $HC = 3$ ) Halny criteria established. The days without any of the criteria were classified as the zero class ( $HC = 0$ ). For further analyses, days within class 2 or 3 ( $HC > 1$ ) were designated as distinct Halny days and were taken into account. Four seasons were analysed: winter (December, 1 – February 28/29), spring (March, 1 – May, 31), summer (June, 1 – August, 31) and autumn (September, 1 – November, 30).

### Statistical analysis

Three types of statistical tests were used in the study. The  $\chi^2$  test was used to determine whether an association between two categorical variables was significant. In order to compare the averages, we used a one-way ANOVA test. In the case of two factors, their interaction was assessed by a two-way ANOVA test. The daily suicide risk (DSR) during the Halny wind was calculated by dividing the total number of suicides committed during the Halny wind by the total number of Halny days in 16 years. The relative risk (RR) of suicide was calculated as the ratio of the DSR during the Halny days and the DSR in the remaining period.

## RESULTS

### Seasonality of suicides

During a 16-year period (1999–2014) a total of 210 (168 males and 42 females, sex ratio 4:1) committed suicides were registered in the Tatra County, resulting in a crude suicide rate of 20.2 per 100,000, ranging from 12.3 (in 2012) to 33.8 (in 2003). There was no difference in the DSR between the seasons (one-way ANOVA,  $F(3, 5840) = 0.081$ ,  $p = 0.97$ ). The DSR was respectively 3.5% (95% confidence interval, CI 2.5–4.5%) in the winter, 3.8% (95% CI 2.8–4.8%) in the spring, 3.5% (95% CI 2.6–4.5%) in the summer, and 3.5% (95% CI 2.5–4.5%) in the autumn. There were two suicides per day in five cases. The average age was similar in males (45.4, standard deviation,  $SD = 18.1$ ) and females (47.9,  $SD = 18.2$ ). There were no differences in the sex ( $\chi^2 = 4.02$ ,  $df = 3$ ,  $p = 0.26$ ) and the age group ( $\chi^2 = 8.58$ ,  $df = 9$ ,  $p = 0.48$ ) in each of the seasons (Tab. 1).

### Seasonality of Halny

In the observed 16-year period (5,844 days), the estimated number of Halny days was 963 (16.5%). The number of Halny days varied significantly in different seasons (one-way ANOVA,  $F(3, 5840) = 45.521$ ,  $p < 0.0001$ ): it was the highest in the winter (329/963 = 34.2%) and in the autumn (292/963 = 30.3%). In the spring, there were 224 Halny days (23.2%). The lowest number of Halny days (118) was in the summer (12.3%). The number of Halny days (for both classes) is shown in Tab. 2.

### The relationship between Halny and suicides

It was estimated that 14.5% (31/210) of suicides took place during the Halny wind. The DSR during Halny was not significantly different from the DSR in the remaining period ( $\chi^2 = 0.44$ ,  $df = 1$ ,  $p = 0.51$ ).

The RR of suicide during the Halny wind was estimated at 0.88 (95% CI 0.60–1.28). Halny days (as well as 2 days before the Halny wind) did not modify the risk of suicide, regardless of gender, age, duration and the class of the Halny wind ( $p > 0.05$ ), 2 days before the Halny wind also did not modify the risk.

However, the Halny wind modified suicide risk depending on the season (two-way ANOVA,  $F(3, 5836) = 3.52$ ,  $p = 0.014$ ) (Fig. 1a). The interaction was even more

The number of the Halny days	Winter	Spring	Summer	Autumn
$HC > 1$ , n = 963 (%)	329 (34.2%)	224 (23.3%)	118 (12.3%)	292 (30.3%)
$HC = 2$ , n = 724 (%)	250 (34.5%)	163 (22.5%)	106 (14.6%)	205 (28.3%)
$HC = 3$ , n = 239 (%)	79 (33.1%)	61 (25.5%)	12 (5.0%)	87 (36.4%)

Tab. 2. Seasonality of Halny in the Tatra County – 1999–2014

Halny	Winter RR (95% CI)	Spring RR (95% CI)	Summer RR (95% CI)	Autumn RR (95% CI)
Two days before Halny	0.85 (0.44–1.64) $p = 0.635$ n.s.	0.93 (0.45–1.89) $p = 0.848$ n.s.	1.36 (0.69–2.67) $p = 0.37$ n.s.	0.56 (0.25–1.23) $p = 0.149$ n.s.
Halny days HC > 1	0.83 (0.42–1.63) $p = 0.583$ n.s.	0.10 (0.01–0.73) $p = 0.023^*$	1.50 (0.63–3.43) $p = 0.341$ n.s.	1.51 (0.83–2.75) $p = 0.181$ n.s.
Halny days, HC = 3	0.17 (0.01–2.66) $p = 0.205$ n.s.	0.20 (0.01–3.22) $p = 0.258$ n.s.	4.87 (1.33–17.8) $p = 0.017^*$	2.50 (1.10–5.72) $p = 0.030^*$

Tab. 3. The seasonality of the RR of suicide during Halny in Tatra County – 1999–2014

significant in class 3 of the Halny wind [two-way ANOVA,  $F(3, 5836) = 5.47$ ,  $p < 0.001$ ] (Fig. 1b).

The RR was more than four times higher in the summer and more than twice as high in the autumn as well as ten times lower in the spring, depending on the Halny classes (Tab. 3).

The Halny wind seems to be the risk factor for suicide in summer and autumn. However, suicides in the period of two days before the Halny did not depend on the season of the year.

## DISCUSSION

Similar to Deisenhammer et al. (2003), but contradictory to other researchers (Odewald, 1939; Rohden, 1933; Schiffer, 1986; Trepińska et al., 2005), we found that the overall number of the foehn winds did not increase the number of suicides. We observed the seasonality of the Halny wind, as it blows mostly in the autumn and the winter (typically in the Alpine region (Richner and Gutermann, 2007), but determined lack of seasonality in the case of suicides. Nevertheless, the Halny seems to increase the suicide risk in the summer and the autumn, especially on class-3 foehn days. Hypothetically, the increase in suicides in the summer might be related to the influence of higher temperatures, and in the autumn to the influence of spherics (short-duration, low-intensity electromagnetic impulses that are

generated by lightning and other electric discharges in the atmosphere) on both the serotonin and melatonin system (Christodoulou et al., 2012; Deisenhammer, 2003; Fountoulakis et al., 2016; Hiltunen et al., 2014; Kim et al., 2011; Lee et al., 2006; Reiter, 1960, 1993). Insufficient levels of melatonin may cause disturbances in the circadian rhythm, exacerbate sleep problems and painful conditions as well as increase the severity of chronic inflammatory lesions in the brain which might trigger suicidal behaviour. Although studies on spherics (Sulman et al., 1975) and positive ions (Krueger and Reed, 1976) suggest that there may be more suicides 1–2 days before the arrival of foehn, we did not confirm these findings.

Our study has several limitations. Firstly, the inconsistency between the results of our research and the local beliefs on the influence of foehn on suicides may be related to the fact that we explored only selected determinants of the complex pathways to suicidal behaviour. A suicide death is a multifactorial outcome of human behaviour with a prominent role of individual vulnerability, resilience to suicidality and many other suicide risk factors as well as the protective ones (Wasserman and Wasserman, 2009). Another limitation of our study is that we have examined a complex of meteorological variables of foehn wind, such as changes in the temperature, atmospheric pressure, humidity, wind direction and speed as well as the type of clouds, but none of these variables was analysed separately. We did not analyse other

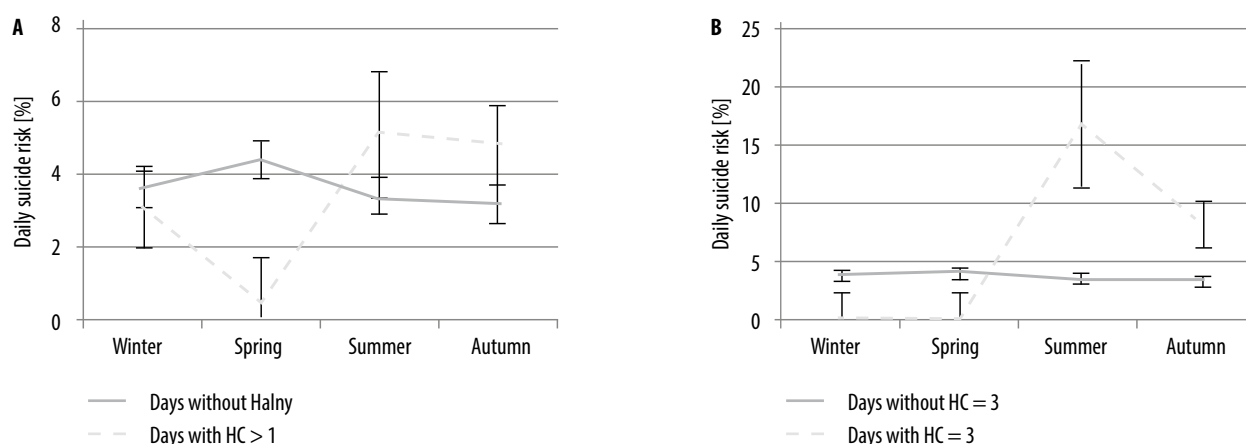


Fig. 1. The seasonal DSR during HC > 1 (A) and HC = 3 (B) in the Tatra County – 1999–2014

accompanying features, such as positive ions, spherics, pollution, microfluctuations of the air pressure and acoustic effects. The biometeorological influence of the foehn on suicides may be related to a particular individual weather-sensitivity (Yackerson et al., 2012) which was not investigated in this study. All the features described above may have a profound effect on the body and mind of the people living in the mountains. Despite a long observation time, the sample was relatively small, which is a common problem in the research on a rare phenomenon in a small region (Fountoulakis et al., 2016).

A better understanding of the influence of the foehn wind on suicides in some geographic regions may require coordinated research as well as modern technology [e.g. instruments to analyse spherics (Reiter, 1960, 1993; Sulman et al., 1975), positive ions (Krueger and Reed, 1976), electrodermal activity (Thorell, 2016), brown adipose tissue (BAT) (Partonen, 2012), circadian rhythms (Frank et al., 2013; Landgraf et al., 2014; Maestroni et al., 1986) and resilience to suicidality (Yackerson et al., 2012)].

The interrelation between the environment, the local culture and individual neurobiology may be the missing link helping us bridge the gap between the theory and practice in suicide prevention. The effects of foehn winds on mood and suicidal ideation should be examined in future by adequate study designs in the regions affected by these strong and sudden meteorological phenomena.

### Conflict of interest

*The authors do not report any financial or personal affiliations to persons or organisations that could negatively affect the content of or claim to have rights to this publication.*

### Appendices

*The research has been approved by the act No. 37/16 of the Bioethics Committee of the Regional Medical Chamber in Warsaw, Poland.*

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